HYBRID PHOTOVOLTAIC CONCENTRATING SYSTEM WITH CORRECTED TOTAL REFLECTION REFLECTORS FOR VERY LARGE CONCENTRATING RATIOS

A. GENERAL- FIELD REVIEW

The construction of Concentrating Photovoltaic Systems with conventional parabolic reflectors or with parabolic total reflection reflectors is a well known technology for many years.

However though and in spite of the fact that the factor Photovoltaic Cells does not seem to be an insuperable difficulty (since their cost is antistrophe-analogous with the sun concentration), however until today there are no concentrating P/V systems in the market, cheaper than the conventional (expensive) flat P/V systems.

The reason is that the construction of parabolic Total Reflection Reflectors (TRR) from common water-clear glass, which would be the cheapest and the most time resistant solution, with unlimited life time, it comes up against constructional difficulties which do not allow large concentrating ratios.

The main cause is the fact that the parabolic TRR from glass, have due to their construction, for technical reasons, rear rectangular prisms with larger height and width than the ones made out of acrylic (2-10 mm those of glass compared to 0,02-0,2mm of the acrylic ones).

But the Rectangular Prisms appear diffusion and poor focusing of the solar rays, which as a matter of fact gets worse exponentially as their height and their width increase, limiting that way drastically the concentration ratios.

Moreover this imperfection limits the use of secondary reflectors used for the shrinking of the solar image size and the achievement of a Narrow Secondary Beam and high level of concentration ratios which would be necessary for the feeding of hollow Solar Wave Guides (Solar Arteries) for the transfer of solar radiation inside the buildings in order to be used for solar lighting,

The same imperfection limits the construction of hollow Solar Wave Guides (Solar Arteries) with small losses for the transfer of the Solar Radiation inside the buildings for the replacement of the artificial with solar lighting.

Until today there have been efforts for the transfer of solar radiation inside the buildings by using large diameter fiber optics. This method though even for the most clear fiber optic materials, appears great losses for the solar spectrum (e.g. 50% losses for 20-30 meters distance).

B. GENERAL DESCRIPTION OF THE ADVANTAGES OF THE PRESENT INVENTION

The present invention consists in the development of total reflection reflectors for the construction of various solar or other concentrating type systems with very large concentrating ratios for the simultaneous production of electrical and thermal power, which consist of concentrative Total Reflection Reflectors, with Curved Rectangular Total Reflection Prisms, which do not present the imperfection of diffusion and poor focusing of the solar rays, like the conventional known TRR with rectangular total reflection prisms.

The correction of this imperfection will allow the construction of Parabolic TRR made of common water-clear glass with large dimensions (height and width) of the rectangular prisms of the Parabolic TRR (size 2-10mm or even larger) as it is technically necessary for the technology of the glass while simultaneously there will exist the possibility of excellent focusing with large (real) concentrating ratios (500 or 1000 suns or even more), while in the same time will be made possible the use of Secondary Parabolic or Ellipsoidal Total Reflection Reflectors, for the shrinkage of the solar image's size and the achievement of even larger (real) concentrate ratios (over 1500 suns) as well as the creation of the Narrow Secondary Beam of Rays with beam-angles sized from 5^0–10^0 for the feeding of the Solar Radiation into Solar Wave guides for its transfer inside the buildings for solar lighting.

Moreover the construction of Solar Wave Guides with minimum losses for the effective transmission of the solar radiation to sufficiently long distances with an acceptable losses-level (e.g. for the internal lighting of buildings with solar light).

C. DESCRIPTION OF THE DRAWINGS

In the Drawing 1a is shown a full parabolic Total Reflection Reflector.

In the Drawing 1b is shown the Detail A for the formulation of the Curved Rectangular Prisms for the correction of the Diffusion-Imperfection of the conventional Parabolic Total Reflection Reflectors (due to the simple Rectangular Prisms).

In the Drawing 1c the typical construction of a hollow Solar Wave-guide with total reflection walls (Solar Artery) is presented.

In the Drawing 1d is presented the Detail A' which shows the implementation of the Curved Rectangular Prisms, which raise the imperfection of the diffusion of the conventional Solar Artery (due to the simple conventional Rectangular Prisms).

The Drawing 2 shows the Solar System S/S (100_A), which concentrates the solar energy and transforms it into a Narrow Beam for the production of electrical and

thermal energy or the introduction into hollow Solar Wave-guides (Solar Arteries). The Drawing 3a shows the Solar System S/S (500_A) where the Solar Artery is also used to transfer the Solar Energy into the building for Solar lighting. The Drawings 3b and 3c present the Angular Accessory (571_A) and the Multiple Angular Accessory (581_A) for the feeding or the bleeding of the Solar Radiation into Solar Arteries.

D. DETAILED TECHNICAL DESCRIPTION

Below is given the detailed technical description of the Solar Systems S/S (500_A), (100_A), (600_A), equipped with the new corrected parabolic Total Reflection Reflectors (TRR) (001_A) with corrected Hollow Rectangular Prisms (HRP) (007_A) or ($007'_A$) and with the new Solar Arteries (551_A) with corrected Hollow Rectangular Prisms (556_A) or ($556'_A$) for the raise of the imperfection of the diffusion and bad focusing of the conventional parabolic TRR and Solar Arteries (because of the simple Rectangular Prisms) and the achievement of high concentration.

1.Solar System of Single Point Focusing S/S (500_A) for Solar Lighting, Air-Conditioning and Water-Heating in Buildings

The Solar System S/S (500_A), which is shown in the Drawings 1a, 1b, 1c, 1d, 2 and 3a, 3b, 3c, is characterized by the fact that it is equipped with corrected Primary Parabolic Total Reflection Reflector (501_A) and Secondary Ellipsoidal Reflector (201_A) aa well as the corrected Solar Arteries (551_A) and the Accessories of the Arteries (571_A) and (581_A), which are all equipped with Curved Rectangular Prisms (CRP) (007_A), (CRP) ($007'_A$) and (556_A) correspondingly, as all these are shown in the Drawings 1a, 1b, 1c and 1d, and as they are described in the Paragraphs 4 and 5 below, so that the imperfections of the simple conventional rectangular total reflection prisms are raised.

It is characterized also by the fact that it is designed for the supply of Solar Lighting in a building and the simultaneous production of cooling and thermal energy.

Also by the fact that the construction of the Structural Elements of the S/S (500_A) is effected as it is described below:

The primary Parabolic Total Reflection Reflector (PTRR) (501_A) [which is referred as (101a) as well] consists of a full parabolic reflector or of an extract of any form of the full reflector. The primary PTRR (501_A) can consist of for example 1,2,3,4 or even more Tiles of Total Reflection (TTR) (131_A) based on an appropriate parabolic substrate, each-one with main dimensions 20x20cm approximately so that the (TRR) (131_A) can be produced at a low cost by existing automated glass-impression machines. The material of the (501_A) and (131_A) consists e.g. of water-clear glass without iron oxide or of transparent plastic self-supporting or supported on an appropriate substrate (as it is shown in the Drawings 2 and 3a).

The Front Surface (113_A), of the TRR (131_A) has a smooth parabolic form, while the Rear-Surface (113_r) is also parabolic and bas-relief and consists of Corrected Rectangular Prisms (007_A) [which are referred as (114_A) as well], of which the Top

Acmes (115_A) converge and meet at the Top (102_A) of the full Parabolic Total Reflection Reflector (101_A) [which coincides here with the primary PTRR (501_A), while the cross-sections of the sides of the Corrected Rectangular Prisms CRP (114_A) or (007_A) are not straight-lines but are the corrected curves of the CRP (114_A) or (007_A) so that an accurate focusing is succeeded.

The S/S (500_A) has the Symmetry Axis as well (551_A) (which points to the sun) and the Rotation Axes (512_A) and (512_Γ) (Horizontal and Vertical correspondingly).

The primary PTRR (501_A) is based on a metallic Supporting Frame (505_A) (e.g. structured as the parabolic plate of a satellite television antenna made of pressed aluminum sheet), which is based on the Vertical Rotation Mechanism (508_A), which is based on the Horizontal Rotation Mechanism (508_B) [analogous with the Mechanisms (108_A) and (109_A) below] and with the help of the two Bearings (508_Γ) it is based on the Supporting Base (510_B).

The Secondary Total Reflection Reflector (STRR) (201_A) consists of a full paraboloidal or ellipsoidal reflector [depending on whether it is placed in front or behind of the Focus (504_A) or (104_A), in the present occasion it is placed behind the Focus (504_A) and it is ellipsoidal] or of an extract of any shape [analogous of the corresponding (501_A)] and is made of the same material as the corresponding (501_A).

The STRR (201_A) can also consist of e.g. 1,2,3,4 or even more Total Reflection Tiles (TRT) (231_A), as they are shown in the Drawings 2 and 3 and are based on the metallic Supporting Frame (507_A) which is based on the Supporting Frame (505_A).

The Front Surface (213_A) of the TRT (231_A) has a smooth ellipsoidal by rotation form while the Rear Surface (213_Γ) is also ellipsoidal and bas-relief and consists of Corrected Rectangular Prisms (214_A), whose Acmes (215_A) converge to the Top (202_A) of the (201_A), while the cross-sections of the Sides (233_C) of the Corrected Rectangular Prisms (CRP) (214_A) are not straight-lines but they are the corrected curves of the CRP so that an accurate focusing is accomplished.

The primary Total Reflection Reflector (501_A) [corrected with CRP (007_A)] creates the Wide Beam of Rays (052_A), which incides and is reflected backwards by the Secondary Reflector (201_A), which here is designed ellipsoidal by rotation in appropriate size and is placed behind of the Focus (504_A), so that it shrinks to the desirable grade the Solar Image and this way the Narrow Beam of Rays (053_A) is created with the desirable beam angle (e.g. smaller than $\pm 5^0$)

It is also characterized by the fact that the S/S (500_A) possesses a Reflection Medium (231_Γ) of the Narrow Beam of Rays (053_A) before it focuses on the Focus ($504'_B$) (e.g. a Total Reflection Reflector with parallel rear surface total reflection prisms) placed in a 45^0 angle towards the Narrow Beam Axis (053_A), very close and behind the Focus ($504'_B$) and very close to the Entrance of the Solar Artery (551_A) so that it

reflects the Narrow Beam (053_A) into the Solar Artery (551_A), which is placed with its opening close to the Focus (504_A) of the reflected Narrow Beam (053_A) and its Axis (553_A), which is parallel to the one of (053_A). In those occasions or during that time of the day when the Solar Lighting is not needed inside the building, the TRR (231_r) or some of them may be drawn away, and thus the Narrow Beam will focus straight onto a selective black absorbent surface (562_A) which is placed on the Focus ($504'_B$) which will transfer the heat of the Beam (053_A) into the Working Fluid (502_E) [which will be utilised as hot water or as cooling power used for air-conditioning through the Adsorption Heat Pump (519_A) with Silicagel etc].

It is also characterized by the fact that alternatively the Reflection Medium (231_r) of the Narrow Beam of Rays (053_A) before it focuses onto the Focus ($504'_B$) may be a Cold Mirror (231_r) at a 45^0 angle towards the Narrow Beam Axis (053_A), which does not need to be too close to the Focus ($504'_B$) or too close to the Solar Artery (551_A) and which will only reflect the visible part of the spectrum (from λ=0,4 until λ=0,7μm) with a coefficient of reflectivity above 96%, at an angle of 90^0 towards the Solar Artery (551_A) [which is placed with its Opening at the Focus (504_A) of the Narrow Beam (053_A) and its Axis (553_A) parallel to the one of (053_A)], while it will allow the infrared (IR) part of the spectrum (from λ=0,7 to λ=2,4μm) to get through it with very few absorption losses in the order of 5-10%. The IR part of the Narrow Beam (053_A) will focus straight onto a selective black Absorbing Surface (562_A) placed at the Focus ($504'_A$), which will transfer the heat of the IR Beam (053_A) to the Working Fluid (502_E) [which will be utilized as hot water or as cooling power used for air-conditioning through the Adsorption Heat Pump (519_A) with silicagel etc) avoiding at the same time to transfer the heat of the IR part of the solar spectrum into the building, saving that way the corresponding power of the Chiller of the Air-conditioning Units of the building.

The reflected Narrow Beam of Rays (053_A) will be focused on the Center (552_A) of the Solar Artery (551_A), which is placed very close to the final Focus (504_B) with the Axis (553_A) of the Solar Artery parallel to the Narrow Beam Axis (053_A). The Solar Artery (551_A) is constructed as described below in paragraph 5.

Subsequently, the Narrow Beam (053_A) of the total or just of the visible part of the solar spectrum, through the Solar Arteries (551_A) is transferred to the internal of the building so that it is used for natural lighting through special Solar Lighting Fixtures (SLF) (591_A).

For one or many primary Reflectors (501_A) concentrating the Solar Radiation, which have been arranged on a fixed basis or on a rotating basis, which floats, the Solar Arteries (551_A) of each Basic Reflector (501_A) are gathered through Angled Accessories (571_A) to the Main Multiple Angled Accessory (581_A) with which each

Solar Beam (053_A) of the Solar Arteries (551_A) of each Basic Reflector (501_A) are inserted into the Main Artery ($551'_A$) and transferred to the Internal of the Building where the Solar Radiation (053_A) is distributed in the reverse way to each floor by Multiple Angled Accessories (581_A) to smaller Arteries that transmit the light to the rooms we want to illuminate and there the final distribution to lighting fixtures is effected either by Solar Arteries (551_A) of small diameter or by optical fibers of large diameter.

For the achievement of constant level of lighting into the rooms, when the intensity of the available Solar Radiation changes there will be conventional fluorescent lamps which through a Dimmer will keep the lighting level constant, increasing or decreasing correspondingly the lighting flux of the fluorescent lamps.

A first approximation of the energy production or the energy substitution resulting from the Solar System S/S (500_A) in the case of using the Cold Mirror (231_Γ) is the following:

Each KW of incoming solar radiation [which corresponds, at an Ideal Solar Location (ISL) with 0% diffuse and 100% straight radiation at noon with clear sky and AM1,5, with an aperture of one square meter of primary Reflector (501_A)], when it is splitted into visible and infrared (IR) radiation, will give approximately 500W visible and 500W IR radiation.

From the 500W of visible light, using Total Reflection Reflectors and the Solar Arteries as above, approximately 80% of that will be transmitted to the Solar Lighting Fixtures (591_A) inside the building. It is known that each W of visible solar light corresponds to 200lm (compared with approximately 60 lm/W for the state of the art fluorescent lamps which are used for the internal lighting of the buildings).

That means that the transmitted 400W of visible light will give 80.000 lm which will substitute 80.000/60 = 1330 W of electrical energy (=33 fluorescent lamps of 40W).

Moreover they will substitute another 400W of electrical energy, which would have been required from the air-cooled chillers (with COP=2,3) in order to remove 1330-400=930W_{th} thermal load, which remains behind due to the operation of the 1330W fluorescent lamps.

On the other hand the IR radiation, which focuses at the Focus (504_B) on the Absorbing Surface (562_A) will have approximately 15% losses due to reflection and absorption at the Cold Mirror (531_Γ) and emittion from the Selective Absorbing Surface (562_A). Which means that the power of the IR radiation which will be delivered to the Absorbing Surface (562_A) will be equal to 500x0, 85=425W, which will be transferred by the Heating Pump (519_A) (Absorbing or Adsorbing) to the Working Fluid (502_E) as above (producing 425W_{th} of hot water during the winter) or will be transformed into cooling power (as chilled water, with COP 0,7 till 0,9 average

0,8 due to the higher permissible temperatures of hot water) equal to 435x 0,8=340 W for Air-Conditioning Units during the Summer substituting 340/2,3= 150 W of electrical power of the air-cooled chillers, which would have been required by them for the same cooling power.

At the same time the Silicagel Adsorption Heat-Pump (519_A) (which can transform the hot water of 60°-90° C into cold water of 7°/12° C for air-conditioning with a COP of 0,7 approximately) will produce in parallel an intermediate stream of lukewarm water of 30°-32°C from the condensation of the water vapor during the adsorption cycle with a thermal power of approximately 425W, appropriate for pool- heating or for warming-up of domestic hot water etc.

The total attribution of the IR part will be: 150W of substituted electric energy of air-conditioning plus 425W of lukewarm water during the summer or 425W of hot water during the winter.

So the Solar System S/S (500_A) can produce or substitute for each KW of incoming Solar Energy (which corresponds approximately to 1 m^2 of aperture surface of a primary Reflector for an ISL):

-For the part of the Visible Spectrum

- 1330W of substituted electrical energy for building lighting (substitution of 33 fluorescent lamps approximately)
- 400W of substituted electrical energy for air-conditioning

-For the part of I/F Radiation (only hot water and air-condition without P/V):

- 15O W of substituted electrical energy for air-conditioning plus
- 425W for the production of lukewarm water during the summer and
- 425W for the production of hot water during the winter

-Total: 1880W of substituted electrical energy and 425W of lukewarm water during the summer and 1330W of substituted electrical energy plus 425W of hot water during the winter.

This means more than 2,30 KWp during the summer and approximately 1,75 KWp during the winter of substituted or produced electrical and thermal energy for each KWp of incoming solar energy.

Compared with the conventional P/V Systems, which produce approximately 120 till 180Wp of electric energy for each 1000 Wp of incoming solar energy, the present Solar System S/S ($500_{A,B}$) produces or substitutes more than 10 times in electrical and 3 times in thermal or cooling power (for hot water or air-conditioning power) in an affordable price, which will allow the amortization of the Solar System S/S (500_A) in less than 3 years, even without incentives.

2.Solar System of Single Point Focus *S/S* (100_A)

The S/S (100_A), which is described here and shown in the Drawing 2 is characterized by the fact that it includes a full primary Parabolic Reflector of Total (or even simple conventional) Reflection (PRTR) (101_A) with Top the point (102_A) and the fact that the Solar Rays (051_A) after their incidence on the primary PRTR (101_A) create the first reflected Wide Beam of Rays (052_A), which focus on the Focus (104_A) and either they are utilized straight there focusing on the P/V Cells (302_A) with the help of the Auxiliary Reflector (363_A) or alternatively after they reflect on the Secondary Reflector (201_A) [which is supported with the Brackets (207_A) on the Ring (105_A)], they create the Narrow Beam of Rays (053_A), which reaches the Final Focus (201_A) and focuses there on the P/V Cells (302_A) with the help of the Auxiliary (363_B) as well, which are based on the Ring ($105_Г$). The Reflector (101_A) is based on the metallic Supporting Rings (105_A) (External) and (105_C) (Internal), which are supported by the metallic Supporting Brackets (107_A), which are based on the Horizontal Rotating Head (108_A). The Head (108_A) is based on the Pillar / Vertical Rotating Mechanism (109_A), which is based on the Base (110_A).

The Total Reflection Reflector (101_A) consists e.g. of transparent water clear glass without iron oxides [one-piece for small surfaces or consisted of Total Reflection Tiles (TRT) (131_A), which consist part of the Parabolic Surface ($113'_A$) and for larger surfaces based on an appropriate parabolic substrate] or of transparent plastic self-supporting or based on an appropriate substrate. The Front Surface (113_A) of the ($113'_A$) has a smooth parabolic form, while the Rear Surface ($113_Г$) has a bas-relief parabolic form and is parallel with the (113_A) and consists of Corrected Curved Rectangular Prisms (114_A) or (007_A), of which the Top Acmes (115_A) converge and meet at the Top (102_A) of the Reflector (101_A). Moreover we have the Symmetry Axis (111_A) (which aims to the Sun) and the Rotation Axes (112_A) and ($112_Г$) (Vertical and Horizontal correspondingly).

The Secondary Reflector (201_A) has a paraboloid or ellipsoid form by rotation [depending on whether it is placed in front or in the back of the corresponding Focus (104_A) or (504_A), at the present occasion it is designed ellipsoid for shrinking the Solar Image] and may consist of 1,2,3,4 or even more Total Reflection Tiles (TRT) (231_A), of which the Front Surface ($231_Г$) is smooth ellipsoid, while the Rear Surface ($213_Г$) is bas-relief ellipsoid and parallel to the (213_A), and consists of Corrected Curved Rectangular Prisms (CRP) (214_A), of which the Top Acmes (215_A) converge and meet at the top (202_A) of the Reflector (201_A).

3.The Solar System S/S (600_A) for Solar Lighting, Solar Air-Conditioning, Solar Water Heating and Electrical Energy from P/V.

The Solar System S/S (600_A) which is shown in the Drawings 3a, 3b, 3c is constructed like the Solar System S/S (500_A) but it is characterized by the fact that it is designed for the production of Electrical Energy on top of the Solar Lighting and the production of Cooling or Heating power of the S/S (500_A) by adding the Structural Elements which are related to P/V [the P/V Cells (302_A), the focus Auxiliary Reflectors (363_A), the Cables (340_A) and the batteries or the Inverters] to those ones of the S/S (500_A) as mentioned below.
All the Structural Elements (S/E) of the S/S (600_A), which are similar to those ones of the S/S (500_A) and to those ones of the S/S (100_A), are named with the same names and code numbers as the corresponding of the S/S (500_A) and S/S (100_A), but they change the first code number from the 5 or 1 to 6 [for example the Vertical Rotating Axis (512_A) of the S/S (500_A) changes to (612_A) in the S/S (600_A), while the (302_A), (363_A) and (340_A) of the S/S (100_A) change to (602_A), (663_A) and (640_A) in the S/S (600_A) correspondingly] and are modified correspondingly for the functional form of the S/S (600_A) [for example the Absorbing Surfaces (662_A) do not need any more to be covered with selective absorbing radiation layer and the P/V Cells (602_A) may be sensitive to the IR].
For this purpose the P/V Cells IR (602_A), the Cables and the Auxiliary Reflectors (663_A) are added on top of the heat Absorbing Surfaces (662_A) behind the Cold Reflector (631_Γ) on the Final Focus (604_B), thus exploiting the incident concentrated radiation first for the production of P/V electrical energy and afterwards for the production of hot water as above.

4.Corrected Parabolic and Paraboloid or Ellipsoid Total Reflection Reflectors with Curved Rectangular Prisms.

In the following text a detailed technical description of the construction of the new parabolic Total Reflection Reflectors (TRR) (001_A) with Curved Rectangular Prisms (CRP) (007_A) for the correction of the imperfection of the diffusion and bad focusing of the conventional parabolic TRR (due to the simple rectangular prisms) and the accomplishment of high concentration ratios is given.
In the Drawing 1a a full parabolic Total Reflection Reflector (001_A) is shown, which is characterized by the fact that it is equipped with the exterior Bas-relief Surface (002_A), which bears Curved Rectangular Prisms (CRP) (007_A) as they are shown in the Drawing 1b.

In the Detail A in the Drawing 1b the Rectangular Prism $H_1\Theta H_2$=007_A is shown, which results as a section of the External Surface (002_A) with the Plain (013_A) vertical to the tagential of the Acme (012_A) of the (non corrected yet) Rectangular Prism (007_A) at the Point Θ. The Plain (013_A) is vertical to the Internal Surface (004_A) at the point O_1 and its section with the (004_A) in the area of the Point O_1 is with great approximation a Periphery Π_1 of a circle with a radiant $O_1 E=\sqrt{2} x O_1 E_0$.

For simplicity reasons of the analysis we suppose that the Focus E_0 of the (001_A) is located on the section of the Plain (005_A) with the Axis (003_A), that the Point K'_1 is located on the Periphery (005_A) and that the Periphery Π_1 =(013_A) has a Diameter Δ_1 = 360cm/π = 114,6cm, consequently the length of the Periphery Π_1=(013_A) equals with $\frac{360}{\pi}\cdot\pi$ = 360 cm and supposing that the parabolic TRR (001_A) includes 150 Rectangular Prisms (007_A), results that the width of each Rectangular Prism (007_A) corresponds on the Π_1 =(013_A) to an arc with length of 2,4 cm or to an angle $\varphi=2,4^o$.

We consider the vector Component AK_1 of the incident Solar Ray (006_A) =$A_0K'_{10}$, which coincides with the section K'_1E of the Plain that is defined by the incident Solar Ray (006_A)=$A_0K'_{10}$ in combination with its parallel Axis (003_A) of the (not corrected yet) parabolic TRR (001_A) with the Plain (013_A). The Ray AK'_1=K'_1E falls vertical on the Periphery (013_A) at the point K'_1 at the area of the (not corrected yet) Rectangular Prism 007_A (where $O_1K'_1$=1,0 cm and $\varphi1=1^0$), penetrates at a straight line to the interior of the Rectangular Prism (007_a) and falls onto the Side $H_1\Theta$ to the point K_1 under an angle of 44^0 to the vertical $K_1\Lambda_1$ and is reflected under an angle of 44^0 and intercepts the Side ΘH_2 at the point K_2 under an angle of 46^0 to the Vertical $K_2\Lambda_2$ and is reflected under an angle of 46^0 to it and emerges from the TRR (001_A) at the point K'_2 under an angle of 3^0 as to the K'_2 Δ" [(which is vertical to the Tangent K'_2O_1" of the Periphery Π_1 =(013_A) at the Point K'_2]. The Vertical $K'_2\Delta$" comes through the Center E of the Periphery Π_1=(013_A) and is the desirable route of the projection of the emerging Ray $K'_2\Delta$ in order that it focuses at E and consequently the real Ray $K'_{20}\Delta"_0$ focuses at E_0[1].

Which means that it is proved that a conventional Rectangular Total Reflection Prism appears an aberration angle φ_4 (Convergence Aberration) of the emerging vector component Ray K'_2 Δ (after the Total Reflection of the vector component Ray AK'_1 as above) as to the desirable routing $K'_2\Delta$" for accurate focusing, equal to $3\varphi_1$ (where φ_1 is the angle that corresponds to the arc $O_1K'_1$) and the same Convergence Aberration presents the real emerging Ray $K'_{20}\Delta"_0$.

[1] For this analysis has been accepted a diffraction coefficient n=1,5 for common water clear glass and that $\sin\varphi_4/\sin\varphi_3$ = 1,5 = φ_4/φ_3 with a very good approximation due to the very small angles φ_4 and φ_3

It is therefore obvious that due to the existence of the Convergence Aberration $\varphi_4=3\varphi_1$, in order to have a tolerable Focusing with conventional (not corrected) parabolic TRR, these must be obligatorily of a very small thickness wall e.g. of colorless plastic (acrylic etc) and the height and width of their Rectangular Prisms to be as small as possible so that the Convergence Aberration to be as small as possible correspondingly, [because the φ_1 is almost straight proportional with the height (008_A) = ½ width of (009_A) of the corresponding Rectangular Prism (007_A) for a given Diameter D= (010_A) =(005_A) of the Parabolic TRR (001_A)].

In contrast in the parabolic TRR made of common water clear glass with n=1,5 and dimensions of height-width of the Rectangular Prism of the order of 2-10 mm as above, if the correction of the Convergence Aberration $\varphi_4=3\varphi_1$ will not be done with Curved Rectangular Prisms (007_A) as given below, then the Convergence Aberration for the previous example with Periphery Π_1=(013_A) = 114,6 cm and Δ= (005_A) = 114,6 / $\sqrt{2}$ =81 cm and Height (008_A)= $^1/_2$ Width (009_A) of the Rectangular Prism in the Periphery Π_1= (013_A) equal to 1,2 cm, incidence of the Ray A at a distance O_1K_1 =1,0cm from the Point O_1 and Focusing Distance $K'_{20}E_0$=114,6 / $\sqrt{2}$ =81 cm, we will have $\varphi_1=1^0$ and $\varphi_4=3^0$ and an aberration of the Reflected Ray $K'_{20}\Delta_0$ from the Point E_0 of the Focus equal to 81*tan3^0=4,25cm (for Rays A_1 incident to the Point H_1 the aberration grows larger than 5,1 cm). Consequently the theoretical ratio of concentration is limited below 250 (and in the reality due to imperfections of the projection the Solar Image etc even more) with a consequence that such a parabolic TRR is completely inappropriate for P/V Concentrating Systems with concentrating ratios larger than 200 or even less.

Therefore in order to have an accurate focusing of the Emerging Ray $K'_{20}\Delta''_0$, this and the vector component Ray $K'_2\Delta$ must take the direction of the straight line $K'_2\Delta''$ which is vertical to the tangent K_2O_1'' at the point K'_2 and therefore passes through the Center of the Periphery Π_1 =(013_A) so that the real Ray $K'_{20}\Delta_0''$ comes through the Focus E_0 [in the following as above the analysis will be made for the vector components on the plain of Π_1 = (013_A), which will stand for the real Rays as well].

This means that the vector component $K'_2\Delta$ of the Ray $K'_{20}\Delta_0$ must be turned anticlockwise (to the left) by an angle of $\varphi_4=3\varphi_1$ and for n=1,5 the vector component $K'K'_2$ of the Ray $K_{20}K'_{20}$ in the Rectangular Glass Prism (007_a) must be turned anticlockwise by an angle of $3\varphi_1$ /1,5 =$2\varphi_1$ which means that the sides $H_1\Theta$ and ΘH_2 must be turned at the points K_1 and K_2 [the $H_1\Theta$ clockwise (to the right) and the ΘH_2 anticlockwise correspondingly] by an angle of $\varphi_1/2$ each of them.

At the specific example above in order to have the revolution of the vector component Ray $K'_2\Delta$ by an angle of 3^0 (so that it coincides with the vertical $K'_2\Delta''$ and route

through the Focus E) the side $H_1\Theta$ must be turned around the point of total reflection K_1 clockwise by $1{,}0^0/2=0{,}5^0$ (consequently the vector component Ray K_1K_2 will be turned clockwise, according to the clock hands, by $0{,}5^0x2=1{,}0^0$) and the side $H_2\Theta$ must be turned around the point of total reflection K_2 anticlockwise by $1{,}0^0/2=0{,}5^0$ (and consequently the vector component Ray $K_2K'_2$ will be turned anticlockwise, opposite to the clock hands, by $0{,}5^0x2=1{,}0^0$), that is in total the vector component Ray $K_2K'_2$ will have been turned anticlockwise by $1{,}0^0 +1{,}0^0 =2{,}0^0$ and the $K_2\Delta$ will have been turned anticlockwise by $2{,}0^0x2=3{,}0^0$ and will coincide with the direction $K_2\Delta''$, which is vertical onto the tangent $K'_2O''_1$ at the point K'_2 (and consequently it will be routed through the Focus E).

It is proved this way that in order to focus correctly the reflected rays emerging by total reflection from a parabolic or ellipsoidal or paraboloidal[2] reflector with a rear surface formulated into converging (at the top of the parabolic or ellipsoidal or paraboloidal reflector) rectangular prisms, then the sides of the rectangular prisms must be rectangular only in a small (dz) area around the top Θ' of each Curved Rectangular Prism (007_A).

At whatsoever other point of them the sides of each rectangular prism must appear, at their projection on a plain vertical to the Acme (012_A) of the Parabolic TRR (001_A), an angle of curvature φ_2 equal with the half of the angle φ_1 , where φ_1 is the angle formatted by the tangent of the internal Periphery $\Pi_1=(013_A)$ at the point K'_1 as above with the tangent of the Periphery $\Pi_1=(013_A)$ at the Central Point O_1. This means that it must go that $\varphi_2 =1/2\ \varphi_1$ at each point K_1 of the sides of a Curved Rectangular Prism (007_A) where the relative each time K_1 corresponds to the each time Points of interception of the incoming vertically [onto the internal Periphery $\Pi_1=(013_A)$] vector components of the Rays A_0 onto the relative Side $H_1\Theta$ of the Rectangular Prism (007_A) [the analysis is effected with the vector components of the rays on the plain of the $P_1 =(013_A)$ as above].

In this way each Side $\Theta'H'_1$ and $\Theta'H'_2$ of the Curved Rectangular Prism $H'_1\Theta H'_2=(007_A)$ made of for example common water clear glass (with a diffraction index n=1,5), it will present an increasing curvature in relation to the corresponding Sides ΘH_1 and ΘH_2 of the Rectangular Prism $H_1\Theta H_2$, whose angle of curvature φ_2 at the each time Point K_1 or K_2 of the $\Theta'H'_1$ and $\Theta'H'_2$ will be equal with great approximation with the half of the corresponding angle φ_1 at the each time points K'_1 or K'_2 of the internal Periphery Π_1 as above, while at the top Θ' we will have a

[2] The analysis is effected on the projections of the Rays (006_A) on the plain of the $\Pi_1=(013_A)$. Consequently are valid go what are mentioned also for the case of the paraboloidal or ellipsoidal (TRR) ($001'_A$) onto which the incident rays $A'=(006'_A)$ are not parallel to the Axis ($003'_A$) of the ($001'_A$) but they originate from a Point ($012'_A$) of the Axis ($003'_A$) of the Paraboloidal (TRR) ($001'_A$)

rectangular intersection of the $\Theta H'_1$ and $\Theta H'_2$.

The need for the construction of parabolic or ellipsoidal or paraboloidal TRR (001_A) or (201_A) or ($201'_A$) with curved Rectangular Prisms as above, becomes even more compulsory when we want to use ellipsoidal or paraboloidal Secondary Reflectors (201_A) or ($201'_A$ or (231_A) which must transfer the Focus (204_A) or (504_B) behind the Primary Reflector (001_A) or (101_A) or (501_A) shrinking or disappearing the Solar Image in order to succeed very big concentration ratios (over 1500 suns).

In this case the focusing must be accurate both in the Primary as well as in the Secondary Reflector, which needs also relative Curved Rectangular Prisms (007_A) as above, but where the exact relationship of the each time angle φ_2 with the corresponding φ_1 both in the each time Primary and the Secondary Ellipsoidal or Paraboloidal Reflector will be determined by a suitable Computer program depending on the each time needs of focusing as above.

5. Corrected Solar Arteries and Solar-Arteries-Grid-Elements with Curved Rectangular Prisms

Another application where the construction of TRR with Curved Rectangular Prisms is imperative and essential is the manufacturing of hollow Solar Wave-Guides (Solar Arteries) with small losses or small leakage of radiation to the outside so that the transportation of Solar Radiation in great distances with acceptable losses is achieved, for example for the transportation of Solar Radiation inside a building for the substitution of artificial with solar lighting.

The Drawing 1c shows the typical construction of a hollow Solar Wave-guide with total reflection walls (Solar Artery).

The Drawing 1d shows the Detail A, which shows the implementation of Curved Rectangular Prisms that raises the imperfection of diffusion in the conventional Solar Artery (due to the conventional Rectangular Prisms).

The Solar Artery (551_A) consist of a hollow Pipe with thin Walls (554_A) from transparent material with very small absorption-factor of solar radiation for example special transparent plastics or other clear materials by which are manufactured optical fibers, as the PMMA or the fused silica or even water-clear glasses without iron - oxides.

The internal wall of the Pipe is smooth, cylindrical with a diameter from a few centimeters (or even smaller) up to tens of centimeters (or even bigger). The external wall of the pipe is bas-relief and is constituted by many, parallel between them [and to the axis (553_A) of the Pipe], Curved Rectangular Prisms (556_A) as these is defined

below.

The Walls (554_A) of the Solar Arteries have their Internal Surface smooth, cylindrical, while their external surface is also cylindrical, bas-relief with parallel and at the same time Curved Rectangular Prisms (556_A), whose Acmes (557_A) are parallel to the Axis (553_A) of the Solar Artery and their Acmes-Angles (558_A) will be 90^0 only in a small area near the Acmes-Angles (558_A). The external surface of the Curved Rectangular Prisms (556_A) will be covered with a suitable transparent Protective Layer (562_A), as those that are used for the protection of the external surface of the optical fibers in the telecommunications and finally this will be protected by an External Plastic Mantle (563_A). The diameter of the Solar Artery (551_A) will be big enough so that the focused Narrow Beam (053_A) at the end of the (551_A) near the focus will be inside a circle of optical angle e.g. 10^0-20^0, when we look at it from the Periphery (555_A) of the section of the Artery (551_A) towards the Center (552_A) [dependent from the index of refraction of the water-clear material of the) Artery Walls (554_A] in order to be inside the total reflection angle of the Curved Rectangular Prisms (556_A) as well as the relative angle of the Solar-Arteries-Elements (571_A) and (581_A) equipped with Total Reflection Reflectors (571_A) and (581_A) as they are mentioned below.

A Beam of Rays (053_A) (Beam) must enter into such a Solar Artery (551_A) from its one end in such a way that the Focusing Point ($504'_B$) of the Beam (053_B) coincides with the Center of the Opening (552_A) of the Solar Artery (551_A) and the Symmetry-Axis of the Beam (053_A) to coincide with the Symmetry-Axis (553_A) of the Solar Artery. The Focusing Point ($504'_B$) of the Beam (053_A) is actually not a point but a Circle (Π_2) with a Diameter (Δ_2), where (Δ_2)<(Δ) = Diameter of the Solar Artery, that will be named Entry-Circle (560_A). At the present case the diameter of the Entry-Circle (560_A) of the Beam (053_A) should appear from any point of the Internal Walls (555_A) of the Solar Artery (551_A) under an angle smaller than $2\psi*5^0$ (where the factor $\psi>1$ becomes greater as long as the opening-angle of the Beam becomes smaller e.g. for an opening-angle of the Beam equal to $\pm 5^0$ and index of refraction n = 1,5 the Diameter of the Entry-Circle can become equal with the Internal Diameter of the Solar Artery). The above condition is necessary in order that any Beam of Rays (053_A) insides to the internal surface of any Curved Rectangular Prism (556_A) with an angle smaller than $\psi*5^0$ for an index of refraction n = 1,5 so that we have total reflection of the Solar Beam (053_A) from any Curved Rectangular Prism (556_A) found in their way.

In order to be possible to implement the requirement of incidence under angle $\pm\psi'*5^0$ [where $\psi'*5^0$ = the projection of $\psi*5^0$ in a level vertical to the Axis (553_A)] relative to the radius of the Δ_1 at any point of the internal periphery Δ_1 of the (555_A) the incoming Beam of Rays (053_A) must have an Entry-Circle with Diameter $\Delta_2 < \Delta$ and an opening-angle φ smaller or equal to $\pm x*5^0$ relative to it's axis of transmission, where $0<x<45/9$.

The correction which is imposed by the structure of the Curved Rectangular Prisms causes a behavior in the total reflection of rays in such a way that the projection on a level (Π) vertical το the Axis (553_A) of a ray that incides under an angle $\varphi<\psi*5^0$ on the internal walls of the Solar Artery (551_A), to emerge parallel to the projection on the (Π) of the ray incoming, so as to continue with sequential reflections (where the projection on the Π of each emerging ray is parallel with the corresponding projection on the Π of the incoming ray) to incide always on the next points of incidence on the Internal Walls (555_A) with an angle that ensures the total reflection from the Curved Rectangular Prisms (556_A).

The Rays A_0K_{10} of the Beam (053_A) which incide with a lateral angle φ onto the Internal Walls (where on the projection as above e.g. $\varphi<5^0$ for n=1,5) then due to the lateral peculiarity of the total reflection, they will emerge from their total reflection in the Curved Rectangular Prisms (556_A) towards the same side from where they entered and parallel (in the vertical projection of their routing) to the incident Ray A_0K_{10}. In this way even the Rays, which incide laterally on the Internal Walls (but always with an angle φ e.g. $-5^0 < \varphi<5^0$ for n =1,5) will suffer successive total reflections, where the angle of incidence on the Internal Walls will be within the limits for the achievement of total reflection, since each time it emerges parallel (related to the vertical projection of its routing) with the incident ray, which thus maintains its relative location for total reflection always passing from the interior of the Circle Π_2 = (560_A) [something that ensures always that in the next point of contact with the Internal Wall (555_A) of the Solar Artery (551_A) will also have ensured Total Reflection].

On the contrary without the corrective routing imposed by the Curved Rectangular Prisms (556_A) the Emerging Ray $K_{20}\Delta_0$ from the total reflection would divert from the parallel routing to the incident Ray AK_{10}' [for the example of the Ray A_0K_1' with vertical incidence of its projection in the level Π at the Point K1' of the Internal Wall (555_A) of the Solar Artery] in each total reflection by an angle φ_1 (for n=1,5), where φ_1 is the curvature-angle at the incidence point as is defined above (the same relation will also be valid for lateral incidence as above).

This would have as consequence after some number of total reflections that, due to the algebraic summing of the error of divergences as above, the reflected ray would come out of the limits of the borderline of the Entry Circle Π_1=(561_A), in which limits we have total reflection, therefore this ray in the next incidence would not undergo total reflection on the Internal Walls of the Solar Artery and would come out (loss).

Consequently in the case of the Solar Artery the Curved Rectangular Prisms (556_A) must impose a correction of the routing of the Emerging Ray $K_2'\Delta$ (with left-handed rotation of $K_2'\Delta$) by an angle φ_1 ($1x\varphi_1$ instead of $3x\varphi_1$ as in the parabolic reflectors

above) so that the projection of $K_{20}'\Delta_0$ as above to emerge parallel to the projection of incident Ray A_0K_{10}' (and the $K_2'\Delta$ parallel to the AK_1').

Therefore the K_2K_2' should be turned left-handed by φ_1/n (in the example with $\varphi_1 = 1^0$ by $1^0/1,5 = 0,6767^0$), therefore the sides $H_1\Theta$ and ΘH_2 of the conventional Rectangular Prism should be turned around the points K_1 and K_2 by $\varphi_1/4n$ each one, the $H_1\Theta$ right-handed and the ΘH_2 left-handed respectively (in the example with $\varphi_1 = 1^0$ by $1^0/4x1,5 = 0,1667^0$). That is the sides of the Curved Rectangular Prisms (556_A) will have at each point K_1 a curvature equal to $\varphi_1/4n$ where φ_1 the corresponding angle in each Point K_1' and n the index of refraction of the material of the Solar Artery (again it has been considered that $\sin\varphi_3/\sin\varphi_4 = \varphi_3/\varphi_4 = n = 1,5$ due to the very small angles).

Actually the correction imposed even by the Curved Rectangular Prisms (556_A) for Rays that incident under a lateral angle is not 100% (that is the emerging ray is not completely parallel with the incidence ray), because differences in the required curvature depending on the removal of the total reflection points K_1, K_2 from the central locations that correspond to the reflection of the vertical to the (555_A) incident ray. However, the correction that is imposed with the statistical mutual attenuation of the divergences up or down to the initial incidence-angle (dependant on if the second total reflection falls to the right or to the left from the ideal K_1 or K_2) gives the possibility to the Solar Arteries (551_A) to present losses of at least one order of magnitude smaller than the conventional Solar Pipes(Solar Tubes), which use reflective walls of total reflection, but with Rectangular (and no curved corrective) prisms of total reflection.

This means that for the same percentage of losses e.g. 50% the Solar Arteries (551_A) will be able to transport the Solar Light at least one order of magnitude longer in a building for solar lighting etc (e.g. if a conventional Solar Pipe for 50% losses transports the Solar Light 50 meters, a Solar Artery with Curved Rectangular Prisms will transport it 500 meters or even more for the same level of losses).

Alternative in the Corrected Solar Artery ($551'_A$), which is also constructed as the above mentioned Corrected Solar Artery (551_A) (and it bears structural elements with the same numbers but highlighted with tones) but it is characterized by the fact that the corrective route, which is imposed by the Curved Rectangular Prisms (556_A) to the Emerging Ray $K_{20}\Delta_0$ from the total reflection can impose a divergence from the Incident Ray A_0K_{10}' [for the example of the vector component Ray AK_1' with vertical incidence on the level Π at the point K_1' of the Internal Wall (555_A) of the Solar Artery] in each total reflection by an angle $\varphi_1/4n \leq \varphi_2 \leq 3\varphi_1$, e.g. for angle $\varphi_4=3\varphi_1$ (with n=1,5 as in the case of the parabolic and paraboloidal reflectors in paragraph 1 above and as it is shown in the Drawing 1b Detail A) where φ_1 is the curvature-angle at the incidence point as it is defined above (the same relation will also be valid for lateral

incidence as above) whereupon the $K'_2\Delta$ does not emerge parallel to the AK_1' but converges to the Focus E as in the case of the parabolic and paraboloidal reflectors in paragraph 1 above.

In this case however of the Solar Artery ($551'_A$), the Curved Rectangular Prisms (556_A) must impose a correction on the routing of the Emerging Ray $K_2'\Delta$ (with left-handed rotation of $K_2'\Delta$) by an angle $\varphi_4=3\varphi_1$ (as in parabolic reflectors above). Therefore the K_2K_2' should be turned left-handed by $2\varphi_1$ (in the example with $\varphi_1 = 1^0$ by 2^0) therefore the sides $H_1\Theta$ and ΘH_2 of the conventional Rectangular Prisms should be turned around the points K_1 and K_2 by $\varphi_1/2$ each one, the $H_1\Theta$ right-handed and the ΘH_2 left-handed respectively (in the example with $\varphi_1 = 1^0$ by $0{,}5^0$). That is the sides of the Curved Rectangular Prisms (556_A) will have at each point K_1 a curvature equal to $\varphi_1/2$ where φ_1 the corresponding angle in each Point K_1' and n the index of refraction of the material of the Solar Artery (again it has been considered that $\sin\varphi_3/\sin\varphi_4 = \varphi_3/\varphi_4 = n = 1{,}5$ due to the very small angles).

The optical systems for the transportation of the visible part of the solar spectrum, which use conventional optical fibers (even high-quality fibers) for distances of the order of the 20-30 meters suffer from optical losses in the order of 50%, because does not exist suitable material for all the wavelength-range of the visible solar spectrum (each material of optical fiber is tuned at a special wavelength, outside from which the optical losses increase vertically).

On the contrary all Narrow Beam of Rays (053_A) that enter the Walls (554_A) of the Artery (551_A) internally, they undergo total reflection by the external Curved Rectangular Prisms (556_A) and they emerge again from the internal side according to the laws of total internal reflection, as it is described below, and they travel along the interior of the Artery (551_A) inside the air with minimal losses compared to the conventional optical fibers, constructed from the same quality transparent material (e.g. fused silica, super clear plastic optical fibers etc). Each reflected ray in the Solar Artery (551_A) after each total reflection travels in the interior (551_A) at least 10-100 times bigger length in the air than in the transparent optical material [dependant on the thickness of the Walls (554_A) and the Diameter (555_A) of the Artery (551A)], decreasing thus its absorption losses by an equivalent factor.

Consequently for same distances of transportation of the visible solar spectrum and the same construction material, the use of Solar Arteries (551_A) will decrease the optical losses in a small percentage 5-10% or even smaller of the above reported losses of optical fibers, allowing thus the transport of the visible part of the solar spectrum 10 or 20 (or even more) times longer for the same level of losses.

The Solar Arteries (551_A) in combination with the Corner Elements (571_A) and Elements of Concentration or Distribution (581_A) as are described below that allow

the creation of a Collection-Network (590_A) and a Distribution-Network (590_B) towards the correspondent Solar Lighting Fixtures (591_A) inside the Building [the Lighting Fixtures (591_A) can also be provided with conventional lamps with Dimmers for the compensation of the daily reduction of solar light, during the nights etc.].

The Solar Arteries (551_A) are implemented preferably in straight parts for biggest exploitation of the Opening-Angle φ of the Entering Beam (053_A) (they can also accept changes of the angle of their routing-axis up to the limits that are allowed by the each-time achievement of total reflection)

The requirements of a big change of direction along the routing (e.g. 90^0) are implemented by the Corner Element (571_A), which is constituted by the incoming and out coming Solar Arteries (551_A) (fixed and rotated around their axis) and by one conventional Reflector (574_A) with high reflectivity for the Wide Beam (052_A) with an angle e.g. $-45^0<\varphi<45^0$ or for the Narrow Beam (053_A) with an angle e.g. $-5^0<\varphi<+5^0$ by a Total Reflection Reflector (575_A) with parallel Rectangular Prisms (576_A), whose Top-Acmes (577_A) are parallel to the level that define the axes (578_A) and (579_A) of the Entry Parts (572_A) and Exit Parts (573_A).

The Reflector (574_A) or the TRR (575_A) is placed under an angle of 45^0 to the axis (553_A) of the Solar Artery in order to change the direction of the transmitted Solar Beam (053_A) by 90^0, but can change the placement-angle e.g to 50^0 for the achievement of a change of the direction of the Beam (053_A) by a double-angle, in this case by 100^0.

The Corner Element (571_A) can be also implemented with a Prism ($571'_A$) of right-angle divergence made of a diffractive clear material or crystal or even water clear glass, which functions at $-90^0<\varphi<90^0$, imports however losses of reflection by the entrance and by the exit of the Beam (053_A).

For the entrance of many Beams (053_A) from various small Solar Arteries (551_A) in one bigger it can be used the Multiple Corner Element (581_A) that has a Polygonal Reflective Surface (582_A) constituted from many TRR (575_A) each under an angle of 45^0 to the Axis (553_A) of the opposite Solar Artery (551_A), supported suitably on the perforated against the (551_A) Nutshell (583A) by which (575_A) the Beams (053_A) from various Solar Arteries (551_A) with small diameters enter into a bigger Solar Artery (561_A), or reversely from a bigger Solar Artery ($551'_A$) they come out and are distributed into many smaller Arteries arranged circularly under an angle of 90^0 to the Axis ($553'_A$) of the ($551'_A$).

The Multiple Corner Elements can be also materialized by the frustum-cone-shaped (internally) Prism ($581'_A$) from a material as the ($571'_A$), which however imposes an increase of the angle φ and losses of reflection of entrance-exit.

Finally for the subtraction of Solar Radiation from a bigger Solar Artery ($551'_A$) to a

smaller one (551_A) we use the Subtraction Corner Element ($571'_A$), which is constituted by a circular Conventional Reflector ($574'_A$) or TRR ($575'_A$) that it is placed under an angle of 45^0 inside the bigger Solar Artery ($551'_A$) and sends the reflected, under a corner of 90^0, Solar Beam (053_A) through the lateral Circular-Opening (562_A) into the smaller Solar Artery (551_A) that begins with a diameter equal with the diameter of the Opening (562_A).